Designed in 1933 : The Curtiss-Courtney amphibian had a retractable nose wheel as well as retractable main wheels. In addition to being almost buried while in flight, the nose wheel of the amphibian formed a useful fender when coming up to moorings.

undercarriage which was familiar in the earliest days of flying, but that the two-wheeler should have persisted for so long.

What has caused the two-wheeled undercarriage to be the source of these landing difficulties is the fact that the wheels must be placed ahead of the centre of gravity of the machine; otherwise there would be a marked tendency to nose over on making contact with the ground. The "three-point" landing which is the ambition of every beginner can be traced to the division of the weight of the machine, when on the ground, between the two main wheels and the tail wheel. With the tail wheel on the ground, most aeroplanes will remain in that attitude even if the wheel brakes are applied at fairly high speed, and unless the brakes are put on fairly brutally, there is no risk of nosing-over, thanks to the forward position of the wheels.

The modern multi-wheel undercarriage reverses the process. The two main wheels are placed behind the centre of gravity, and the third wheel is situated under the nose of the fuselage. Thus when the wheels touch, there is a tipping action which raises the tail and brings the front wheel into contact with the ground. This raising of the tail brings the wings to a smaller angle of incidence, thereby reducing their lift and preventing the machine from becoming air borne again. Moreover, the wheel brakes can be applied quite hard, the nose wheel preventing the machine from turning over.

Ancient History

All this was realised by designers in the early days of flying, and nearly all the early aeroplanes had either skids or wheels for preventing nosing-over. Sometimes skids and front wheels were combined in one undercarriage. What led to abandoning the wheel-cum-skid undercarriage was the high drag usually associated with undercarriages of this type, and it was not very long before the simple two-wheeled undercarriage, with two vee struts and a cross-axle, became almost universal.

Now that retractable undercarriages have come into general use, both at home and abroad, it is but natural that an effort should be made to combine the desirable qualities of the tricycle arrangement with the retractable feature, and it is along these lines that the majority of designers are working.

Mention was made above to one exception from the general scheme of two-wheels-behind-the-c.g.-one-wheel-in-front. This is the undercarriage produced in 1936 by British Landing Gears, Ltd., and tested experimentally on an old Avro Avian at Hanworth (see *Flight* of June 18, 1936). In the Cowey-Eugster undercarriage the main wheels are farther ahead of the c.g. than in the orthodox undercarriage, and the third wheel is under the fuselage, aft of the pilot's seat. The rear wheel is well sprung, and prevents the machine from "ballooning" even in a hard landing at fairly high speed. It is understood that developments are proceeding and that an undercarriage of the Cowey-Eugster type, made retractable, is to be tested on a military aircraft shortly.

Recently General Aircraft, Ltd., of Hanworth, have been making flying tests with a tricycle undercarriage fitted to one of their Monospar machines. The arrangement is shown in the photographs and it will be obvious that it is intended for experimental tests only, as it is not retractable. Such features as the placing of the wheels in relation to the centre of gravity can, however, be tried out. It will be obvious that many things have to be taken into consideration. For example, if the main wheels are too far aft of the c.g., the speed which has to be attained before the elevator control is powerful enough to depress the tail will be needlessly great. On the other hand, if the distance is too short, a tail-down landing would tip the nose up, and the main object of the arrangement would be defeated. It is interesting to learn that General Aircraft have come to the conclusion that the tricycle undercarriage is so well worth while that they even regard the abandonment of the present fashionable low-wing monoplane as warranted, and a reversion to the high-wing arrangement. The latter has other advantages, including a better view for the passengers, and General Aircraft's idea of how such a machine might appear is illustrated in the two views of a model of a four-engined high-wing monoplane. It will be observed that with this arrangement the height of the cabin floor above the ground is quite moderate, and passengers will certainly appreciate the level floor.

Anglo-U.S. Experiment

One of the first, if not actually the first, to realise the advantages of the retractable tricycle landing gear was an Englishman, Captain Frank Courtney, who, in 1933, began the design of an amphibian pusher flying boat for the Curtiss-Wright company. The main wheels retracted into the sides of the hull, and the front wheel could be withdrawn into a cavity in the nose of the hull. The fact that the nose had to be watertight made the task more difficult, but Capt. Courtney solved the difficulty in the manner shown in two of our pictures. The strut of the front wheel telescoped into a streamline fairing above the nose. This post was used as a hand hold when mooring the machine. With the front wheel retracted, the tyre projected slightly and formed a very useful bumper or fender.

Capt. Courtney, who has now returned to England, points out that a not-very-obvious but highly important advantage of the tricycle landing gear, from the operators' point of view, is the time saved in taxying. Due to the possibility of applying the brakes hard without fear of nosing-over, the machine can be taxied at high speed to the other side of the aerodrome when wind direction makes this necessary.

Right but not retractable. The Coanda Bristol monoplane of 1912 had its main wheels behind the c.g., and front wheels to prevent nosing-over.